kidney tissue. This organism had been injected into the circulation of a rabbit and at various periods after the injection pieces of the kidney were transferred into the culture media. In these experiments we found not only that both kidney tissue, stroma and parenchyma, and organism may grow side by side in the culture media, but that under certain conditions the growth of the kidney cells may be quantitatively increased.

It will be of interest to extend these studies to other well-defined microorganisms and to test the effect of their metabolic products and direct action on tissue growth.

3. The stereotropic sensitiveness of connective tissue cells can very well be observed in the process of atresia of the ovarian follicle. At a period when the degeneration of the granulosa has set in, connective tissue cells begin to grow from the surrounding theca into the follicular cavity and to fill it more or less completely. Here we can notice that usually the connective tissue cells do not grow directly into the cavity but move in contact with the wall of the follicle, thus forming a peripheral layer of connective tissue which gradually enlarges as more cells are added.

In certain cases, however, we may observe that connective tissue cells grow directly into the cavity. In these cases it is probable that the viscosity of the follicular fluid is relatively great and that a viscous fluid may permit a direct ingrowth of some tissue cells.

LEO LOEB

DEPARTMENT OF PATHOLOGY,
BARNARD SKIN AND CANCER HOSPITAL,
ST. LOUIS

ON AN INTERPOLATION FORMULA USED IN CALCULATING TEMPERATURE COEFFICIENTS FOR VELOCITY OF VITAL ACTIVITIES, TOGETHER WITH A NOTE ON THE VELOCITY OF NERVE CONDUCTION IN MAN

INQUIRIES, both written and verbal, have come to me asking for information concerning a formula which has been employed in some of my physiological papers on temperature coefficients.

In this communication I wish to answer these inquiries (1) by referring to the antecedents and mathematical significance of the formula as briefly as I may, and (2) by giving one or two examples of its application.

In the first place it must be stated that the formula in question, so far as my work is concerned, is entirely an empirical one. Wherever a series of quantities varies with some exponential factor the formula has been found to be fairly satisfactory for extra- and interpolation. Its origin, as far as I (who am not a mathematician) know, is probably "lost in antiquity." Professor Max Bodenstein, of Hanover, has told me, however, that he thought Berthelot first used it in chemistry. Just lately I find that Bodenstein[1] himself made use of the formula in 1899 for the determination of the temperature coefficient of chemical reaction velocities.

On the other hand, the formula of van't Hoff[2] and Arrhenius,[3] among others, were developed from thermodynamic considerations and therefore have important theoretical foundations.

However, the formula I use,

$$\left(\frac{k_1}{k_0}\right)^{\frac{10}{t_1-t_0}} = Q_{10} \qquad (1)$$

is practically the same, I find, as one of van't Hoff's,[4] namely,

$$\log_{10} k = a + bt. \qquad (2)$$

For if the values of k in (2) for two different temperatures are known, then this equation may be derived:

$$\frac{k_{t+10}}{k_t} = 10^{10 \cdot b}. \qquad (3)$$

Equation (1) is probably more convenient for the calculation of quotients for intervals of 10 degrees (temperature coefficients), but it is also more cumbersome for the calculation

[1] Bodenstein, M., *Zeitschrift für physikalische Chemie*, 1899, Bd. 29, S. 332.

[2] Van 't Hoff, "Etudes de dynamique chimique," 1884, p. 115.

[3] Arrhenius, *Zeitschrift für physikalische Chemie*, 1899, Bd. 4, S. 226; "Immunochemie," Leipzig, 1907.

[4] Van 't Hoff, *Vorlesungen über theoretische und physikalische Chemie*, 1898, I., S. 224.

of the value of k. This appears from the following:

From equation (1) we have

$$\log_{10} k_1 = \log_{10} k_0 + \left(\frac{t_1 - t_0}{10} \cdot \log_{10} Q_{10}\right),$$

whence

$$k_1 = 10^{\log_{10} k_0 + \left(\frac{t_1 - t_0}{10} \cdot \log_{10} Q_{10}\right)}. \quad (4)$$

Of course in order to use the simpler equation (2) one must calculate out the values of the constants and these vary, it must be remembered, with the nature of reaction involved.

And now for an example or two to illustrate the application of these formulæ. Barcroft and King[5] studied the effect of temperature upon the dissociation of hemoglobin. In one series of observations an aqueous solution of pure crystals under 10 mm. Hg pressure showed at 14° C. 92 per cent. saturation; at 38°, 24 per cent. saturation. What is the temperature coefficient for intervals of 10 degrees?

This is answered by using either equations (1) or (3). Substituting the observed values in equation (1) we have

$$\left(\frac{92}{24}\right)^{\frac{10}{38-14}} = Q_{10},$$

whence $Q_{10} = 1.75$, the temperature coefficient for intervals of 10 degrees.

From equation (2) or (4) we can now calculate the values of k for the whole of this series of Barcroft and King's observations.

By comparing equations (1) and (3) it will be seen that $Q_{10} = 10^{10 \cdot b}$. Since $Q_{10} = 1.75$, $b = .0243$ and therefore a in equation (2) equals $-.3579$. For the special case under consideration, then, equation (2) reads

$$\log_{10} k = -.3579 + .0243\, t.$$

The table of observed and calculated values of k stands as follows:

Temp. Degrees	k Observed, Per Cent.	k Calculated, Per Cent.
14	92	96
26	56	54
32	38	38
38	24	27

[5] Barcroft and King, *Journal of Physiology*, 1909, Vol. 39, p. 374.

Another and very different example may be taken from the physiology of nerve. As is well known, frog nerve at a temperature of 20° C. conducts the impulse at a rate of about 30 meters per second. It has, furthermore, been shown that the temperature coefficient, or the value of Q_{10} in the above equations, for the conduction time of frog nerve,[6] is about 2.3.

Now if the nature of nerve in both frog and man be essentially the same, the value of Q_{10} is also the same, and from equation (4), which is another expression of (1), we may proceed to calculate the velocity of the nervous impulse in man.

The known values are substituted in (4), taking 37° as the body temperature of man, whence

$$k_1 = 10^{\log_{10} k_0 + \left(\frac{37-20}{10} \cdot \log_{10} 2.3\right)}$$

or $k_1 = 123.6$.

The same result is obtained from equation (2). For since $Q_{10} = 10^{10 \cdot b}$, then $b = .0362$, and for the special case of frog $a = 0.753$, because

$$\log_{10} 30 = a + .0362 \times 20.$$

For the special case of man, then,

$$\log_{10} k = 0.753 + .0362 \times 37,$$

whence $k = 123.6$.

From the above, therefore, we deduce that the velocity of the nervous impulse in man is about 123.6 meters per second. Can this be corroborated by experiment? Happily it can. Professor Piper,[7] of Berlin, has been able to measure the conduction time of the median nerve in man by using the very sensitive and promptly reacting thread galvanometer. From his results he calculates a rate from 117 to 125 meters per second. Using a similar galvanometer, I have been able to confirm this in our laboratory

Charles D. Snyder
The Johns Hopkins University

[6] Snyder, C. D., Archiv für Anatomie und Physiologie. Physiologische Abteilung, 1907, S. 117; *American Journal of Physiology*, 1908, Vol. 22, p. 309.

[7] Piper, H., *Archiv für die gesammte Physiologie*, 1908, 124, p. 591.